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Estimated Water Withdrawals and Use in Vermont, 1995

By Laura Medalie

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BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

For additional information write to:

District Chief
U.S. Geological Survey
New Hampshire/Vermont District
361 Commerce Way
Pembroke, NH 03275

Copies of this report can be purchased from:

U.S. Geological Survey
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CONVERSION FACTORS

Multiply	By	To Obtain
square mile (mi^2)	2.590	square kilometer
gallon per day (gal/d)	0.003785	cubic meter per day
million gallons per day (Mgal/d)	3,785	cubic meter per day

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Abstract

Data on water withdrawals and use in Vermont in 1995 were compiled by major river basin and county as part of a nationwide effort by the U.S. Geological Survey to describe water use in the United States by major water-use categories. Withdrawals in the State in 1995 totaled 570 Mgal/d (million gallons per day). The largest withdrawals were for thermoelectric power (450 Mgal/d), public supply (47 Mgal/d), and commercial use (26 Mgal/d). Other water-use categories included domestic, industrial, mining, livestock, irrigation, and hydroelectric-power use. River basins with the largest withdrawals were the Upper Connecticut-Mascoma (460 Mgal/d) and the Winooski (27 Mgal/d). Concurrently, the largest withdrawals were in Windham (460 Mgal/d) and Chittenden (20 Mgal/d) Counties. Withdrawals from surface-water sources accounted for about 91 percent of total withdrawals; the remaining 9 percent were from ground-water sources. Public-supply withdrawals were distributed to various water users, including domestic, commercial, and industrial. The largest uses of water, including self-supplied withdrawals and public-supplied deliveries, were for thermoelectric power (450 Mgal/d), domestic (45 Mgal/d), and commercial (34 Mgal/d) uses.

INTRODUCTION

Reliable data on water use provide an important tool for water-resources managers and water-supply planners as they strive to ensure that water supplies are adequate to meet demands. These managers and planners analyze water-use data in combination with climatological, hydrological, and demographic data to forecast future water needs and to resolve cases of conflicting demands, such as between withdrawals and instream uses of water. As part of the U.S. Geological Survey (USGS) National Water-Use Information Program, each State compiles data on significant types of water use every 5 years. Selected data from the 1995 water-use compilation for Vermont are presented in this report. The purpose of this report is to provide estimates of water-withdrawal and use data to water-resources professionals and the general public, to compare data among river basins and counties in Vermont, and to present a brief discussion about how the data were derived.

Data on water use were compiled by major river basin and by county. Figure 1 shows these aggregational units and is intended to be used in conjunction with table 1. Table 1 lists river basins and their codes (8-digit hydrologic cataloging unit code) delineated by the USGS, in cooperation with the U.S. Water Resources Council (Seaber and others, 1987). These codes identify river basins shown in figure 1.

Withdrawal and water-use values (unless otherwise indicated) represent estimated average daily use in 1995 and were derived by dividing estimated total annual withdrawals or use by 365 days. Although this derivation procedure may affect the values for use categories that operate seasonally, such as commercial (which includes snowmaking at ski areas) or irrigation, all use categories are reported to a common baseline, thus providing an overall picture of water use in the State. Because seasonal variations are significant for many commercial users, however, a brief seasonal-withdrawal synopsis is presented in the section on commercial withdrawals and use.

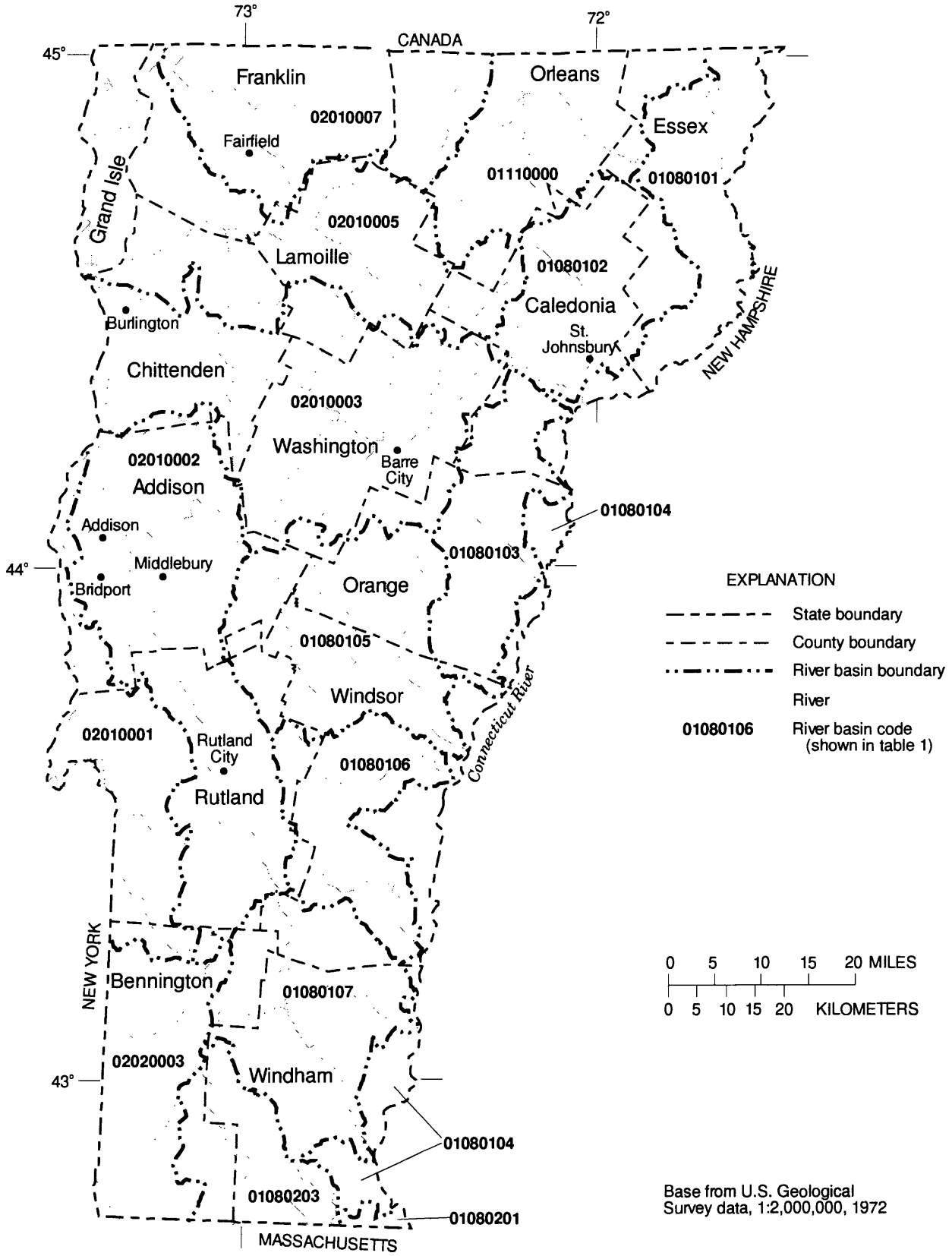

Figure 1. Location of the major river basins and counties in Vermont.

METHODS OF DATA COLLECTION AND COMPILATION

A combination of site-specific and estimated data was used for many of the water-use categories. Site-specific data on water withdrawals or use by the largest water users in Vermont were collected, when available, from State or Federal agencies or by telephone interviews with the water users. Site-specific data were collected for 228 public suppliers, 19 commercial users, 15 industrial facilities, 13 mining facilities, 13 thermoelectric-power and 41 hydroelectric-power facilities.

For most water-use categories, estimated data were used to supplement site-specific data. The estimation technique differed depending on the category of use. Corroborative data were used when available. In general, a water-use coefficient was developed for each category that related water use to an easily obtainable variable specific to that category. These water-use coefficients were derived either from site-specific data compiled during this project or from a related study and were used to estimate the volume of water used by facilities, where site-specific data were not available.

For example, site-specific data were used to develop a per capita public-supply delivery coefficient of 82 gal/d to domestic users. Thus, public-supply withdrawals presented in this report are the sum of site-specific withdrawals (J. L. Rutherford, Vermont Department of Environmental Conservation, written commun., 1996) and, for public-supply systems that did not report withdrawals to the State, withdrawals as estimated by multiplying 82 times the population served. The coefficient for domestic self-supplied per capita water use was estimated as 70 gal/d (Davis and others, 1991). For commercial and industrial water use, water-use coefficients developed by the U.S. Army Corps of Engineers (Davis and others, 1991) were used to relate water use to the number of employees, for different types of industries or commercial facilities. These estimated data were added to known site-specific data for the commercial and industrial categories.

Water use was estimated for only one thermoelectric-power facility; site-specific data were available for 13 other facilities. The estimate for the single facility was made using a coefficient related to power production that was developed for a similar facility with the same cooling-system design. For the mining category, coefficients relating to the number of employees were developed that were specific to the type of mining operation. For livestock, the number of animals by county (U.S. Department of Commerce, 1994) and the number of dairy cows and horses by town (L. M. Degeus, Vermont Department of Agriculture, written commun., 1996) were multiplied by an animal-specific, water-use coefficient (T. E. Buob, Grafton, New Hampshire, County Cooperative Extension, oral commun., 1996). Water for crop irrigation by county was estimated as the difference between the volume of precipitation needed during a typical growing season (May—September) for the irrigated acreage (U.S. Department of Commerce, 1994) and an average county-wide recorded volume of precipitation. This category included irrigation at golf courses.

For 12 of the hydroelectric-power facilities without site-specific data (a total of 76 facilities are in our data base), instream use was estimated from an equation (based on the standard power equation) relating flow to gross head, power production, and turbine efficiency. For the remaining 23 hydroelectric-power facilities, average water-use volumes were used (J. R. Cueto, Vermont Department of Environmental Conservation, written commun., 1995).

Compared to a 1990 water-use map report (Horn and Medalie, 1995) that was also produced under the USGS National Water-Use Information Program, more site-specific data were used in 1995 and many of the estimation methods were further developed. Thus, some of the differences between the two data sets do not reflect actual trends in water use.

ESTIMATED WATER WITHDRAWALS AND USE BY CATEGORY, RIVER BASIN, AND COUNTY

Some water users in each of the categories of this section withdraw surface or ground water from an on-site supply—they are "self supplied" for their water needs. In addition, some domestic, commercial, and industrial water users receive deliveries from public suppliers. Thus, total water use for these categories is the sum of self-supplied withdrawals and public-supplied deliveries. Water use for the remaining categories—mining, livestock, and irrigation—is assumed to be completely from self-supplied withdrawals.

Table 1. Population and total per capita water use in Vermont, by river basins and counties, 1995

[Area includes only the part of each river basin that is contained within the borders of Vermont. mi^2, square mile; gal/d, gallons per day]

River basin code (figure 1)	River basin or county name	Area (mi^2)	Population (thousands)	Population with public supply (thousands)	Total per capita water use (gal/d)
	River Basins				
01080101	Upper Connecticut	527	4.5	1.5	558
01080102	Passumpsic	506	21.0	10.8	173
01080103	Waits	437	15.3	2.9	132
01080104	Upper Connecticut-Mascoma	385	34.6	21.5	13,200
01080105	White	714	28.5	12.3	200
01080106	Black-Ottauquechee	428	20.5	11.2	146
01080107	West	613	20.2	2.5	174
01080201	Middle Connecticut	22	2.1	0.1	90
01080203	Deerfield	316	7.8	1.0	258
01110000	St. Francois	590	20.4	10.6	122
02010001	Lake George	509	20.3	5.8	105
02010002	Otter Creek	1,106	76.7	46.5	229
02010003	Winooski	1,213	150.0	100.6	145
02010005	Lamoille	1,130	102.5	57.0	173
02010007	Missisquoi	664	28.5	10.8	175
02020003	Hudson-Hoosic	454	31.9	19.6	186
	Total	9,614	584.8	314.7	946
	Counties				
	Addison	808	34.8	16.2	161
	Bennington	677	36.3	20.7	185
	Caledonia	658	28.6	13.4	184
	Chittenden	619	139.0	102.5	132
	Essex	673	6.6	2.8	332
	Franklin	692	43.2	20.1	155
	Grand Isle	194	5.9	1.9	1,160
	Lamoille	463	21.1	6.9	172
	Orange	692	27.4	6.8	107
	Orleans	722	25.0	11.4	154
	Rutland	944	62.7	35.8	236
	Washington	695	56.4	32.0	122
	Windham	799	42.8	17.9	9,820
	Windsor	978	55.0	26.3	164
	Total	9,614	584.8	314.7	946

Public Supply

Public-supply withdrawals totaled 47 Mgal/d (tables 2, 3) and accounted for 8 percent of all withdrawals in Vermont. This value represents a moderate increase from the 1990 reported public supply withdrawals of 38.7 Mgal/d (Horn and Medalie, 1995), mostly because of expanded service areas of some of the largest public supply systems in the State. The largest public-supply withdrawals in Vermont were in the Winooski River Basin (fig. 2a), partially coincident with Chittenden County, the county with the largest public-supply withdrawals (fig. 3a). The largest water suppliers in the Winooski River Basin withdraw primarily from surface-water sources and include the Champlain Water District, Burlington Water Department, and the City of Barre Water Department. Lake Champlain alone supplies water for approximately 110,000 people, almost 19 percent of the State's population (J.L Rutherford, written commun., 1996). The Otter Creek River Basin, including the City of Rutland and Middlebury Water Departments, had the second largest withdrawals for public supply.

Public-supply withdrawals do not equal deliveries to domestic, commercial, and industrial users. Some proportion of the withdrawn water is "unaccounted for", as the result of leaks from pipes, nonmetering (for public uses including municipal buildings or fire fighting), poorly calibrated meters or errors, or transfers into or out of the river basin. Unaccounted-for water can be estimated for each river basin or county by subtracting the sum of the columns labeled "public-supplied deliveries" from "public-supply withdrawals" in tables 2 or 3. A resulting negative value indicates imports of public-supply water from another river basin or county. The percentage of total withdrawals that are unaccounted for varies among public suppliers, 10-15 percent is typical. Furthermore, unless a public supplier has an accurate and frequently calibrated metering system, it is difficult to derive reliable estimates of unaccounted-for water, especially if it is a system with older pipes prone to leakage.

Domestic

Domestic withdrawals totaled 19 Mgal/d and accounted for about 3 percent of total withdrawals.

Table 2. Public-supplied deliveries, withdrawals, and hydroelectric-power instream use by river basin in Vermont, 1995

[Units are in million gallons per day (Mgal/d); numbers are rounded to the nearest 0.1 Mgal/d or to two significant figures; values may not add to totals because of independent rounding]

River basin	Public-supplied deliveries			Public-supply withdrawals	Self-supplied withdrawals							Total withdrawals	Hydroelectric-power instream use
	Domestic	Commercial	Industrial		Domestic	Commercial	Industrial	Thermoelectric power	Mining	Livestock	Irrigation		
Upper Connecticut	0.1	0.0	0.0	0.3	0.2	0.0	1.5	0.5	0.1	0.1	0.0	2.8	230
Passumpsic	.9	.1	.0	2.1	.7	1.7	.1	.0	.0	.2	.1	4.9	1,000
Waits	.2	.1	.0	.2	.9	.2	.5	.0	.1	.2	.0	2.0	100
Upper Connecticut-Mascoma	1.8	.7	.6	3.1	.9	.4	1.7	450	.3	.1	.1	460	6,200
White	1.0	.3	.1	1.3	1.1	3.0	.1	.0	.0	.2	.2	6.0	56
Black-Ottauquechee	.9	.2	.0	2.0	.7	1.1	.1	.0	.0	.0	.3	4.1	1,000
West	.2	.1	.1	.3	1.3	1.3	.1	.0	.0	.1	.5	3.5	150
Middle Connecticut	.0	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0	.2	.0
Deerfield	.1	.1	.0	.1	.4	1.2	.0	.0	.0	.0	.2	2.0	370
St. Francois	.9	.1	.0	1.7	.7	.1	.0	.0	.2	.5	.2	3.4	310
Lake George	.5	.1	.0	.6	1.0	.2	.0	.0	.0	.3	.2	2.3	3.9
Otter Creek	3.8	1.2	.8	6.9	2.1	4.1	3.9	.0	.9	1.2	.4	20	2,100
Winooski	8.2	2.2	5.0	19	3.5	2.3	.3	.4	.6	.4	.8	27	2,200
Lamoille	4.7	1.5	.5	3.9	3.2	7.1	.4	.0	.4	.8	.5	16	1,900
Missisquoi	.9	.2	.3	1.5	1.2	.7	.5	.0	.2	1.1	.2	5.4	1,700
Hudson-Hoosic	1.6	.6	.3	3.6	.9	2.1	.2	.0	.3	.1	.2	7.3	93
Total	26	7.7	7.7	47	19	26	9.4	450	3.0	5.3	3.9	570	17,000

Table 3. Public-supplied deliveries, withdrawals, and hydroelectric-power instream use by county in Vermont, 1995

[Units are in million gallons per day (Mgal/d); numbers are rounded to the nearest 0.1 Mgal/d or to two significant figures; values may not add to totals because of independent rounding]

County name	Public-supplied deliveries			Public-supply withdrawals	Self-supplied withdrawals							Total withdrawals	Hydroelectric-power instream use
	Domestic	Commercial	Industrial		Domestic	Commercial	Industrial	Thermoelectric power	Mining	Livestock	Irrigation		
Addison	1.3	0.4	0.2	2.7	1.3	1.0	0.2	0.0	0.2	1.1	0.2	6.7	1,800
Bennington	1.7	.6	.3	3.7	1.1	2.3	0.2	.0	.4	.1	.4	8.2	200
Caledonia	1.1	.2	.1	2.3	1.1	1.8	.6	.5	.0	.3	.1	6.6	1,000
Chittenden	8.4	2.2	4.9	15	2.6	.7	.2	.4	.2	.3	.5	20	2,100
Essex	.2	.0	.0	.5	.3	.0	1.5	.0	.1	.1	.0	2.5	230
Franklin	1.7	.7	.5	3.3	1.6	.4	.6	.0	.2	1.2	.4	7.7	1,800
Grand Isle	.2	.0	.0	.3	.3	6.2	.0	.0	.1	.1	.1	7.0	.0
Lamoille	.6	.2	.0	1.2	1.0	1.4	.0	.0	.2	.2	.2	4.2	350
Orange	.6	.2	.0	.9	1.4	.3	.1	.0	.1	.3	.2	3.2	110
Orleans	.9	.2	.0	1.7	1.0	.7	.1	.0	.2	.8	.2	4.6	420
Rutland	2.9	1.0	.6	4.8	1.9	3.8	3.8	.0	.8	.4	.4	16	340
Washington	2.6	.7	.3	3.9	1.7	1.3	.1	.0	.3	.2	.4	7.9	1,400
Windham	1.5	.6	.5	2.3	1.7	2.6	1.5	450	.1	.1	.3	460	5,600
Windsor	2.2	.7	.2	4.0	2.0	3.2	.5	.0	.3	.2	.4	11	2,100
Total	26	7.7	7.7	47	19	26	9.4	450	3.0	5.3	3.9	570	17,000

About 270,000 people, or 46 percent of Vermont's population, are self supplied for their domestic water use. These values are slightly greater than those for 1990, when domestic withdrawals were 16.5 Mgal/d for 229,500 people (Horn and Medalie, 1995).

The largest withdrawals for self-supplied domestic use and the highest deliveries for domestic use from public suppliers are in the Winooski and Lamoille River Basins (fig. 2b). Large values for domestic water use are seen in these river basins because they have the largest populations among river basins in Vermont (table 1). River basins with the highest percentages of self-supplied population compared to total population are the Middle Connecticut (94 percent) and West (88 percent). However, in all river basins in Vermont, at least 33 percent of the population is self supplied (the Winooski River Basin, has the lowest percentage), because of a substantial (68 percent) statewide rural population (U.S. Bureau of the Census, 1990).

Whereas Chittenden and Windsor Counties have the largest domestic withdrawals (fig. 3b), Chittenden and Rutland Counties have the largest public-supply deliveries to domestic users (table 3). Windsor County, the largest in area of all counties in Vermont, has the second largest self-supplied population. Among the counties in Vermont, Chittenden County has the largest (74 percent) and Orange County has the smallest (25 percent) percent of total population who are publicly supplied (divide population with public supply by population in table 1).

Commercial

Commercial withdrawals totaled 26 Mgal/d and accounted for about 5 percent of total withdrawals in Vermont. This value is a substantial increase from the reported 1990 value of 3.8 Mgal/d (Horn and Medalie, 1995), largely because the 1990 data did not include site-specific data on fish hatcheries and ski areas. In 1995, fish hatcheries accounted for 58 percent (15 Mgal/d) and snowmaking at ski areas accounted for 17 percent (4.4 Mgal/d) of total commercial withdrawals. Other significant commercial water users include hotels and other lodging places, restaurants, personal services such as laundries and car washes, and amusement and recreational services. About 50 percent of the data compiled for this category were from site-specific sources and 50 percent were estimated using

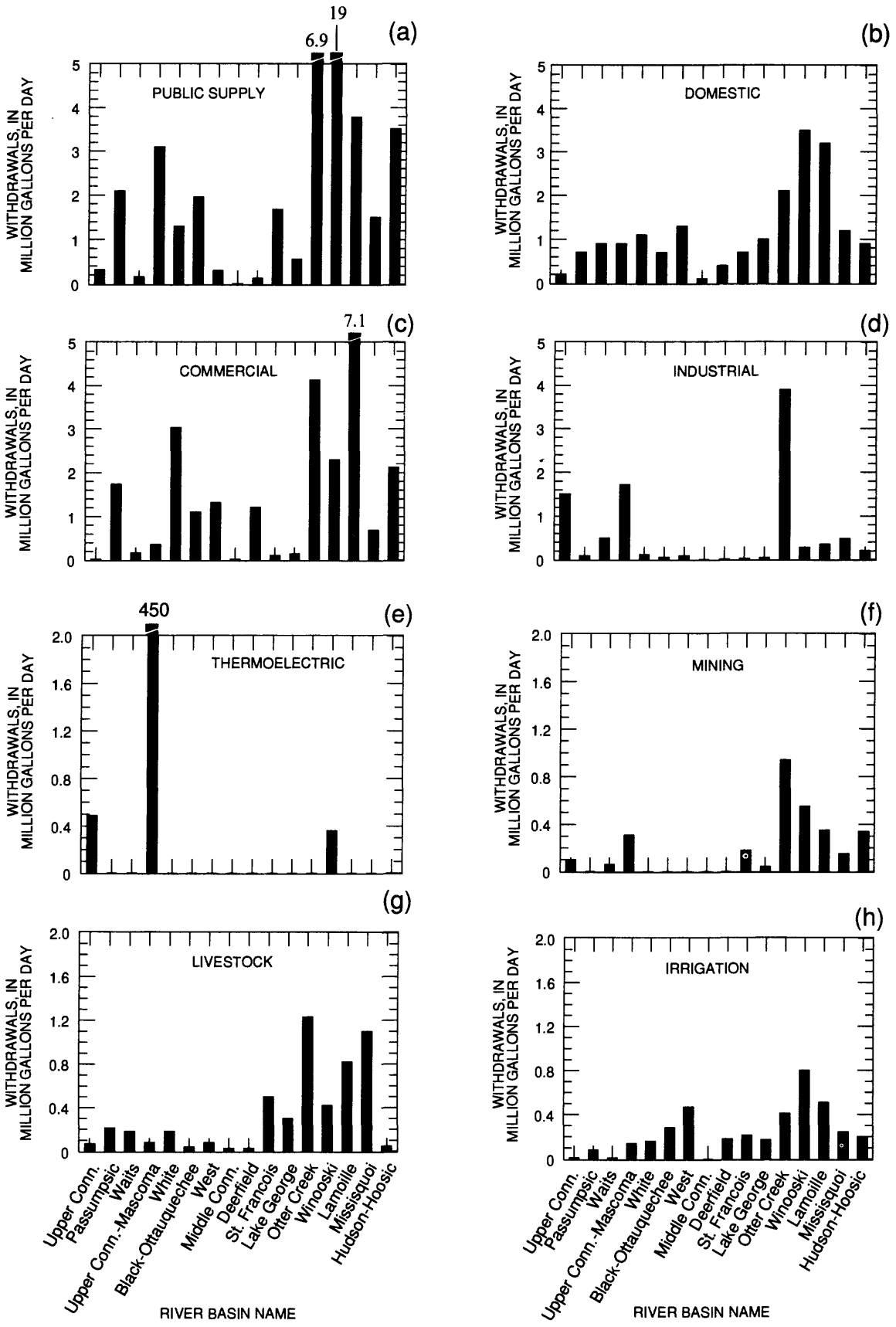

Figure 2. Water withdrawals in Vermont by category of use for river basins, 1995.
[Note that the vertical scales are different for the upper four compared to the lower four charts; Conn., Connecticut]

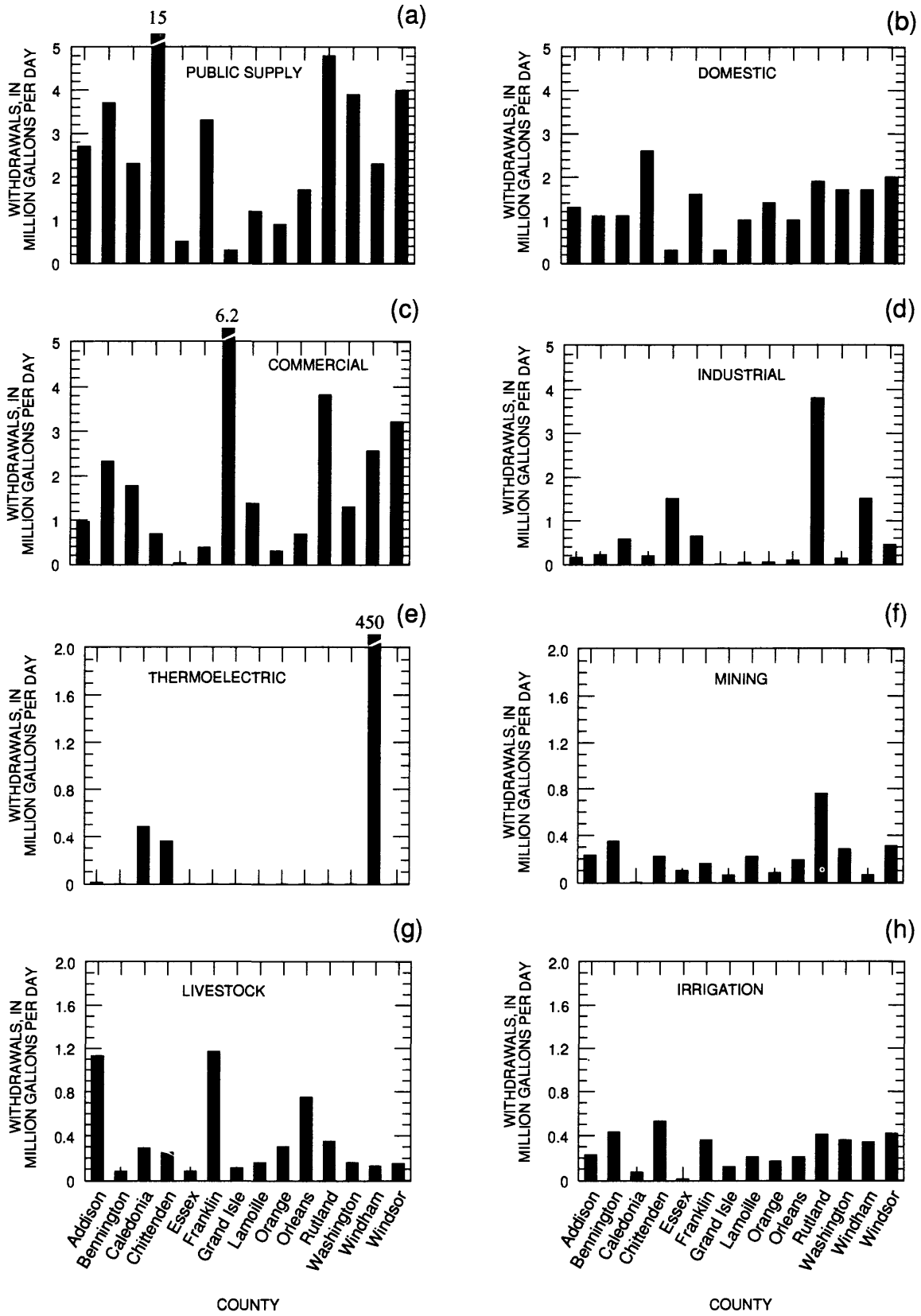

Figure 3. Water withdrawals in Vermont by category of use for counties, 1995.
[Note that the vertical scales are different for the upper four compared to the lower four charts]

water-use coefficients. Commercial withdrawals (fig. 2c) were largest in the Lamoille River Basin, followed by the Otter Creek River Basin. Public-supplied deliveries for commercial use were largest in the Winooski and the Lamoille River Basins.

Grand Isle was the county with the largest commercial withdrawals (fig. 3c), mainly because of a State fish hatchery (fig. 4) that withdraws about 6 Mgal/d from Lake Champlain (M. Walker, State of Vermont Ed Weed Fish Culture Station, oral commun., 1996). Rutland County also had large commercial withdrawals.

Commercial withdrawals with snowmaking and fish hatchery water use estimated on a seasonal basis are shown in figure 5. Withdrawals are largest during the winter (January and February, according to the classification in this report) and fall (November and December), and smallest during the summer (June through October). The two largest commercial uses of water, snowmaking and fish hatcheries, contribute to this seasonal pattern. Water is used for snowmaking only during the winter and fall and sometimes also during March. Water use at fish hatcheries decreases during the summer as adult fish are removed from the hatchery to stock rivers and ponds.

Industrial

Industrial withdrawals totaled 9.4 Mgal/d and accounted for about 2 percent of total withdrawals in Vermont. Most (71 percent) of the decrease from the 1990 reported value of 43.7 Mgal/d (Horn and Medalie, 1995) can be explained by differences in data sources for two individual facilities between the 1990 and 1995 analyses. Industrial withdrawals (fig. 2d) were greatest in the Otter Creek River Basin, followed by the Upper Connecticut-Mascoma River Basin. Public-supplied deliveries for industrial use were largest in the Winooski and the Otter Creek River Basins (table 2). About 72 percent of the data for industrial withdrawals were from site-specific sources (corresponding to the largest water users) and 28 percent were estimated using water-use coefficients. Water-intensive industries in Vermont include electrical equipment, paper, lumber and wood, and food. Counties with the largest self-supplied industrial water withdrawals (fig. 3d) are Rutland, Essex, and Windham. Public-supplied

Figure 4. Raceways at the state of Vermont Fish Culture Station in Grand Isle. [Water is from Lake Champlain.]

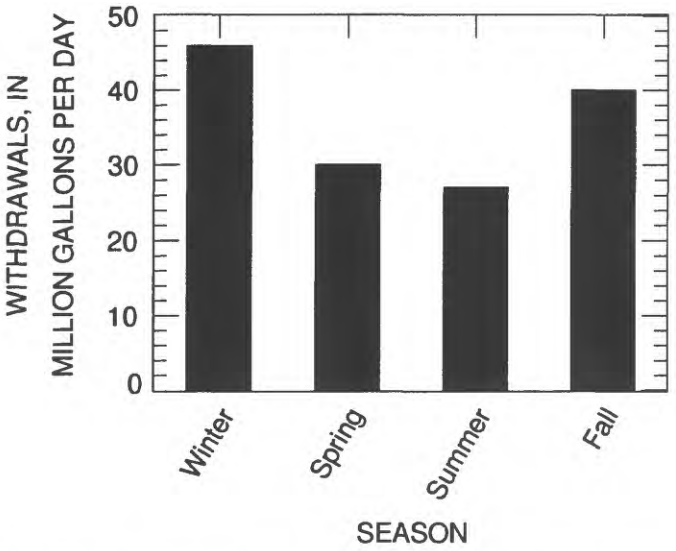

Figure 5. Seasonal commercial water withdrawals in Vermont, 1995.
[Winter, January-February; spring, March-May; summer, June-October; fall, November-December]

deliveries to industrial users are largest in Chittenden and Rutland Counties.

Thermoelectric power

Thermoelectric-power withdrawals totaled 450 Mgal/d and accounted for 79 percent of withdrawals in Vermont. Over 99 percent of thermoelectric-power use is at a nuclear power facility in southeastern Vermont, in the Upper Connecticut-Mascoma River Basin (fig. 2e), Windham County (fig. 3e). This facility has a once-through cooling system, whereby water is withdrawn, circulated in a non-contact chamber for cooling, and returned directly into the Connecticut River. An alternative cooling system used intermittently at that site consists of cooling towers and a spray pond. Although reported thermoelectric-power withdrawals decreased between 1990 and 1995, the methods used to determine withdrawals were different. In 1990, withdrawals for the nuclear facility (518 Mgal/d) (Horn and Medalie, 1995) were estimated to be the maximum possible withdrawals if the plant was continuously operated using the once-through system. The 1995 value is based on actual withdrawals. Thermoelectric-power generating facilities generated 4,400,000 kilowatt-hours of electricity during 1995.

Mining

Mining withdrawals totaled 3.0 Mgal/d and accounted for less than 1 percent of total withdrawals in Vermont. Withdrawals for mining use decreased 0.7 Mgal/d, or 19 percent, from 1990 to 1995 (Horn and Medalie, 1995). Whereas data on the 1990 withdrawals were derived entirely from water-use coefficients, some of the 1995 data were site specific. The 10 largest facilities were contacted during the 1995 analysis and reported lower water withdrawals than would have predicted using the same method of coefficients as was used in 1990. Most of the mining withdrawals in Vermont are by sand and gravel operations. At most mines in Vermont, water is pumped out of abandoned or active quarry holes for dewatering purposes and recycled for mining activities. Many mines have a settling pond on the premises for recycling water that has previously been used for washing or sorting aggregate. River basins with the greatest volume of water used for mining (fig. 2f) are the Otter Creek and the Winooski. Counties with the greatest volume of water used for mining (fig. 3f) are Rutland and Bennington. All water used for mining activities is assumed to be self supplied.

Livestock

Withdrawals for livestock watering totaled 5.3 Mgal/d and accounted for about 1 percent of total withdrawals in Vermont. Withdrawals for livestock use in 1995 were 0.8 Mgal/d less than 1990 reported livestock water use (6.1 Mgal/d) (Horn and Medalie, 1995), which was mainly the result of a decrease in the number of reported dairy cows. About 91 percent of water withdrawals for livestock are associated with dairy cows. The largest number of dairy cows, and resulting livestock water withdrawals (fig. 2g), are found in the Otter Creek and the Missisquoi River Basins. Franklin and Addison Counties have the largest water withdrawals (fig. 3g) for livestock use. Livestock withdrawals were estimated as 75 percent from ground water (4.0 Mgal/d) and 25 percent from surface water (1.3 Mgal/d) (C.E. Altemose, University of Vermont Cooperative Extension, Franklin County, oral commun., 1996). Some of the other animals included in the livestock water-use compilation were horses, beef cattle, sheep, and swine. Although all livestock use is assumed to be self-supplied in conformity with guidelines developed for the USGS national water-use compilation, in Vermont, some farms receive public-supplied water for livestock use.

Irrigation

Withdrawals for irrigation water use totaled 3.9 Mgal/d or less than 1 percent of total withdrawals in Vermont. This volume is a significant increase from 1990 reported irrigation withdrawals (0.5 Mgal/d) (Horn and Medalie, 1995) mainly because golf course irrigation, accounting for about 88 percent of irrigation withdrawals in 1995, was not compiled with the 1990 data. River basins with the largest volume of water withdrawn for irrigation (fig. 2h) are the Winooski, Lamoille, and the West. Counties with the highest volume of water withdrawn for irrigation (fig. 3h) are Chittenden, Bennington, and Windsor. About 80 percent of the irrigation withdrawals are for golf courses and 20 percent is for crops. During the growing season, and in the absence of rain, golf courses are intensively watered at tees, greens, and to a lesser extent, fairways. About 90 percent of the water used for irrigation is lost through evapotranspiration (C.E. Altemose, oral commun., 1996) although the actual amount is affected by many factors such as climatological conditions, soil type, and crop type.

Summary of Withdrawals and Use

Water withdrawals totaled about 570 Mgal/d in 1995. This value represents a 10 percent decrease from 1990 total withdrawals of 632 Mgal/d (Horn and Medalie, 1995), primarily because of the difference in reported thermoelectric-power withdrawals. Total withdrawals (fig. 6a) were highest in the Upper Connecticut-Mascoma River Basin, followed by the Winooski and the Otter Creek River Basins. Counties with the largest withdrawal volumes (fig. 6b) were Windham, Chittenden, and Rutland.

Public suppliers do not really "use" the water they withdraw, but rather they distribute it to various users. Thus, there is a difference between withdrawals and use that should be defined in order to best represent water demands in the State. Total water use for any individual category is the sum of self-supplied withdrawals by water users and deliveries by public suppliers to users in that category. In 1995, total water use in Vermont (fig. 7), averaging 570 Mgal/d, was dominated by thermoelectric power (450 Mgal/d, 80 percent). The second and third largest categories of use were domestic (45 Mgal/d, 8 percent) and commercial (34 Mgal/d, 6 percent). The category, unaccounted-for water, accounts for 1 percent of total water use (5.6 Mgal/d), a larger percentage than the categories of mining, livestock, or irrigation (fig. 7).

Total per capita water use is calculated as total water use divided by total population for a river basin or

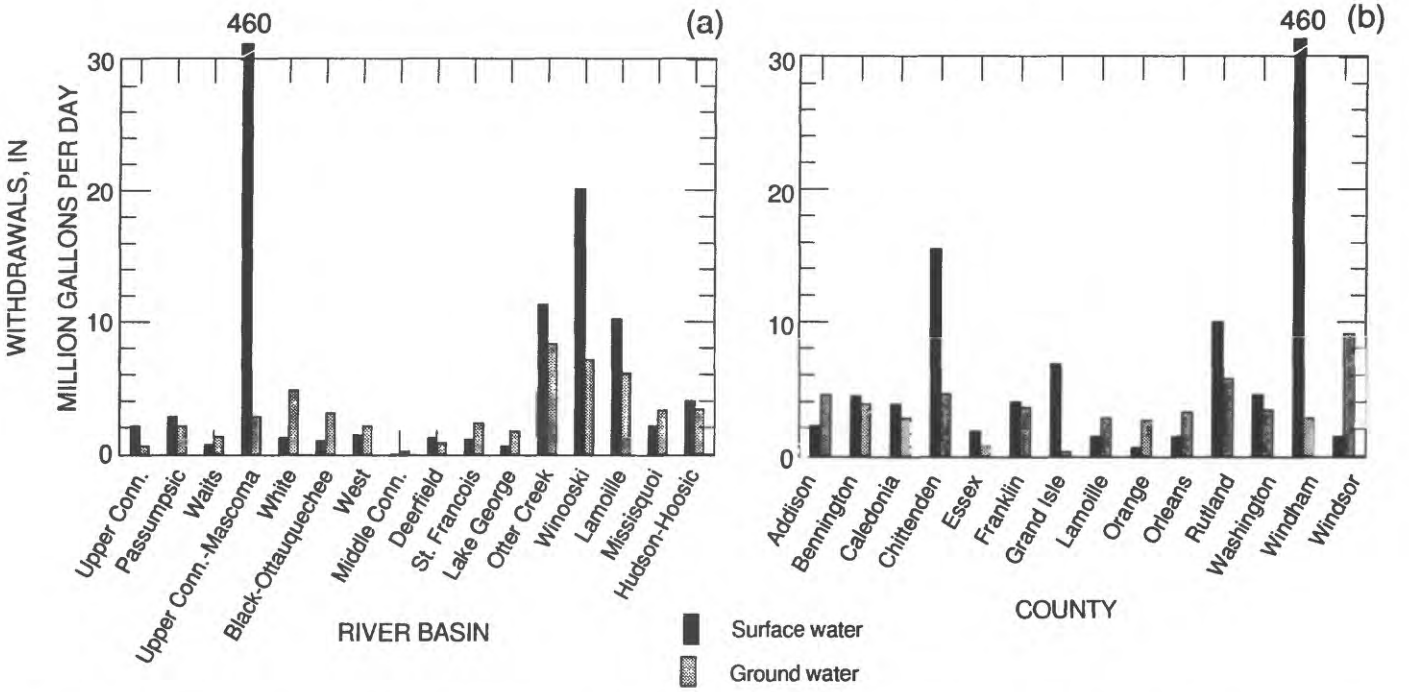

Figure 6. Total surface-water and ground-water withdrawals in Vermont by: (a) river basin, and (b) county, 1995. [Conn., Connecticut]

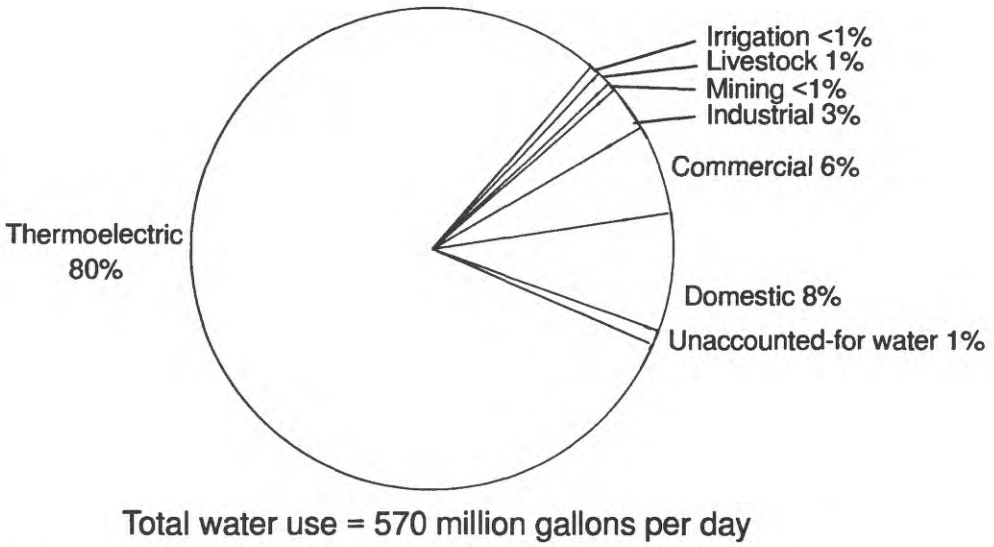

Figure 7. Percentage of total water use in Vermont, by category of use, 1995.

county (last column, table 1). Since domestic self-supplied water use is estimated at 70 gallons per person per day and public-supplied water use at 82 gallons per person per day, a total per capita water use value greater than 82 indicates the presence of either significant water uses besides household use or large unaccounted-for uses (such as imports or exports). The Upper Connecticut-Mascoma River Basin has an extremely high total per capita water use only because the thermoelectric generating facility, which uses 450 Mgal/d of water, is located there. The Upper Connecticut River Basin has high total per capita water use because there are large industrial withdrawals, some water withdrawn by public suppliers is exported to adjacent basins, and there is a relatively low population. Windham County has high total per capita water use for the same reason as the Upper Connecticut-Mascoma River Basin. Grand Isle County has high total per capita water use because of high commercial water use and low population.

SURFACE-WATER AND GROUND-WATER WITHDRAWALS

Withdrawal data organized by source is useful because there are numerous differences in availability, treatment, protection issues, and geographic distribution between surface water and ground water. About 520 Mgal/d (91 percent) of total water withdrawals in the State are from surface-water sources and 50 Mgal/d (9 percent) are from ground-water sources (fig. 6). These percentages are similar to those for 1990, when surface water accounted for 93 percent and ground water for 7 percent of water withdrawals (Horn and Medalie, 1995). As seen in figure 8, the largest volume of surface-water withdrawals, 450 Mgal/d (87 percent), is for thermoelectric-power use, followed by public supply, 32 Mgal/d (6 percent). Domestic and public supply account for 18 Mgal/d and 15 Mgal/d, or 36 percent and 30 percent of ground-water withdrawals, respectively.

Most surface-water withdrawals were in the Upper Connecticut-Mascoma (460 Mgal/d) and the Winooski (20 Mgal/d) River Basins (fig. 6a). Most ground-water withdrawals were in the Otter Creek (8.3 Mgal/d) and the Winooski River Basins (7.1 Mgal/d). Aside from the nuclear thermoelectric-power generating facility in the Upper Connecticut-Mascoma River Basin that contributes to the large surface-water withdrawal in that basin, surface- and ground-water withdrawals are largest in the Otter Creek, Winooski, and Lamoille River Basins within the Lake Champlain drainage, where 56 percent of the State's population resides.

Windham County had the largest volume of withdrawals from surface water (460 Mgal/d), followed by Chittenden County (16 Mgal/d). Ground-water

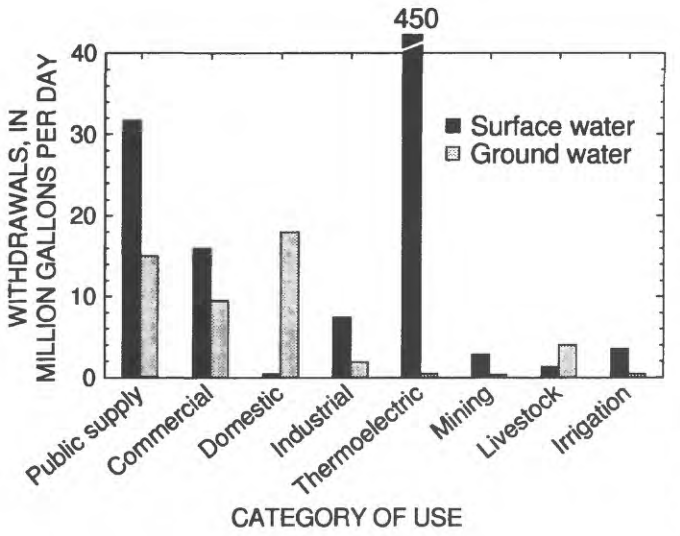

Figure 8. Surface- and ground-water withdrawals in Vermont, by category of use, 1995.

withdrawals were greatest in Windsor County (9.1 Mgal/d) and Rutland County (5.7 Mgal/d) (fig. 6b).

HYDROELECTRIC-POWER USE

In 1995, hydroelectric-power instream use totaled 17,000 Mgal/d in Vermont (tables 2, 3), compared to 17,700 Mgal/d in 1990 (Horn and Medalie, 1995). Water for hydroelectric-power generation is generally used directly in the river. Because water is usually not withdrawn for use offsite, hydroelectric-power use is not grouped with the other categories described in this report. In addition to hydroelectric-power use, there are many other instream uses of water, including fish and other biological habitat, wastewater assimilation, boating, rafting, and swimming, none of which were estimated as part of this study. River basins with the highest hydroelectric-power use are the Upper Connecticut-Mascoma and the Winooski. Counties with the highest hydroelectric-power use are Windham, Chittenden, and Windsor. Hydroelectric-power use generated approximately 983,000 kilowatt-hours of electricity during 1995.

SUMMARY

Selected data from the 1995 USGS water-use compilation for Vermont were presented in this report, compiled by river basin and county. Water withdrawals totaled about 570 Mgal/d in 1995. Thermoelectric-power withdrawals accounted for 79 percent of all withdrawals in Vermont; public-supply withdrawals for 8 percent; self-supplied withdrawals for commercial use, 5 percent; domestic, 3 percent; industrial, 2 percent, livestock, 1 percent; mining, less than 1 percent; and irrigation, less than 1 percent (tables 2, 3). Total withdrawals were highest in the Upper Connecticut-Mascoma and the Winooski River Basins and in Windham and Chittenden Counties. About 91 percent of total water withdrawals in the State are from surface-water sources and 9 percent are from ground-water sources. Total water use for any individual category is the sum of withdrawals by water users and deliveries by public suppliers for users in that category. Hydroelectric instream use was about 17,000 Mgal/d in 1995.

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GLOSSARY:

Water-use categories:

Commercial: use of water in commercial facilities, such as hotels, restaurants, office buildings, hospitals, or schools. Water withdrawn by fish hatcheries and by snowmaking facilities at ski resorts is also included.

Domestic: use of water for household purposes, including water used indoors, such as for drinking and bathing, and outdoors, such as for lawn watering and car washing.

Hydroelectric-power: water used in the generation of electricity at plants where the turbine generators are driven by moving water.

Industrial: use of water in fabricating, processing, washing, and cooling industrial materials.

Irrigation: use of water for irrigation of crops and self-supplied water for golf courses.

Livestock: use of water for watering of livestock and horses.

Mining: use of water in the extraction of minerals, which includes withdrawals associated with quarrying, milling, gravel washing, or dust control. Withdrawals associated with dewatering are included only if the water is used for another mining-related activity.

Thermoelectric power: use of water in the process of generating power from fossil-fuel or nuclear sources. The water is used primarily for cooling.

Other terms:

Evapotranspiration: water evaporated from soil or plant surfaces or transpired (taken up internally by plants and returned to the atmosphere as part of plant metabolism).

Fish hatchery water use: water used for raising fish for later release, used in association with the operation of fish hatcheries or fishing preserves.

Per capita water use: The average volume of water used per person during a standard time period, generally per day.

Public-supply deliveries: Water delivered to a user or group of users through public-supply system distribution lines.

Public-supply withdrawal: water withdrawn by public and private water suppliers who provide water to domestic, commercial, industrial, and other users. Public supply also includes public use, losses, and water transfers to other public suppliers or basins.

Self-supplied withdrawal: Ground-water or surface-water withdrawn by a user and not obtained from a public supplier.

Unaccounted-for water: Water supplied from a public water supply that has not been accounted for as being distributed to domestic, commercial, industrial, or thermoelectric-power users. It includes public water use (firefighting, street washing, and municipal parks and swimming pools), leakage (conveyance loss), and meter errors.